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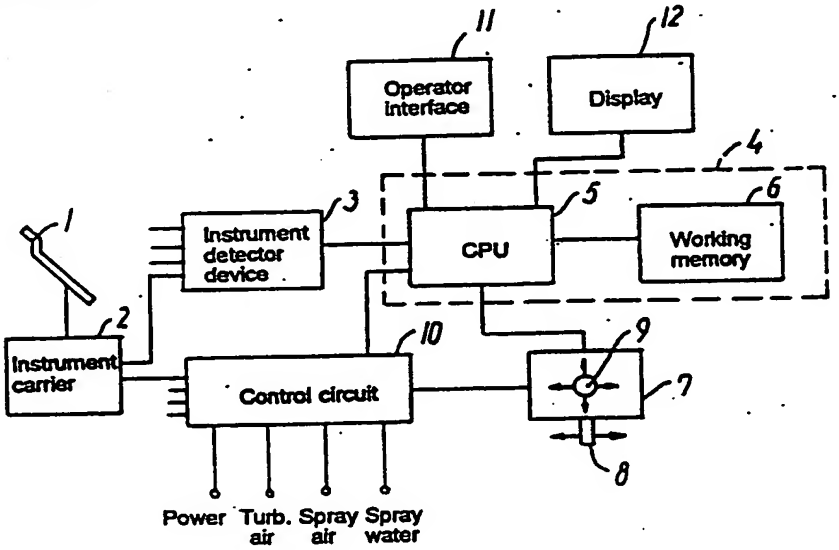

(57) Abstract

In a dental apparatus having an instrument arrangement comprising a carrier (2) for dynamic instruments (1) or instrument hand grips with associated energizing units, a detector device (3) responsive to the removal of an instrument or hand grip from its carrier, an instrument operator device (7) with a movable control member (8) for activating and controlling a selected instrument and for controlling auxiliary functions in conjunction with the operation thereof, a microprocessor (4) is used for monitoring and control of instrument operating functions. For at least one of said dynamic instruments or hand grips, a working memory (6) associated with the microprocessor (4) contains operational parameters for at least two different control variation characteristics for one or more connected control functions for said instrument or hand grip for implementation of said function or functions by the use of said movable control member (8). An operating display for display of the selection of said control characteristics may be associated with the microprocessor (4) as an operator interface and display device.

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A microprocessor controlled dental apparatus having selectable instrument operating functions

The invention relates to a dental apparatus having an instrument arrangement comprising a number of carriers for dynamic instruments or instrument hand grips with associated energizing units, a detector device responsive to the removal of an instrument hand grip from its carrier, an instrument operator device with a movable control member for activating and controlling a selected instrument and for controlling auxiliary functions in conjunction with the operation thereof, and a microprocessor for monitoring and controlling the operating functions of the instruments and their auxiliary functions.

EP patents Nos 42 268 and 42 269 disclose such dental apparatuses providing for obtaining a very extensive simplification and automatization of the dentist's performance of a number of different operating functions in connection with the treatment of patients. With these known apparatuses, a single foot switch is used for the general operation of the dynamic dental instruments when one is removed from its carrier, and for the performance of various auxiliary functions, such as activation of the air blow and preselection of the spray coolant supplied to motor or turbine-driven instruments, the control member of the foot switch being movable both in various directions, and with various durations of the activating movement.

From such dental apparatuses it is further known to use a mode switch-over owing to which the foot switch may further, when the instruments occupy their home positions in their respective carriers, be used for activating a number of auxiliary functions not associated with the operation of the instruments, such as

adjustment of the patient's chair, activation of the fountain flush, filling water in the rinsing glass and calling the dentist's assistant.

In an embodiment disclosed in EP patent No. 0391 967, the intended simplification and automatization has been further developed in that an operating and monitoring display is associated with the microprocessor and has a number of function display fields with associated selective selection switches for activation of the operating and auxiliary functions displayed in said fields.

Thus, by application of modern information technology, a possibility has been provided for the performance of a considerable number of different functions by means of a limited number of operating means, and at the same time a substantially increased informative level and consequently an improved operational security have been obtained.

In connection with this, the total number of operating and auxiliary functions may be organized in a hierarchically structured menu system which substantially contributes to simplifying the operation.

On the basis of a dental apparatus of the type mentioned above, the object of the invention is to provide a possibility of a further individual control of the operation of selected dynamic instruments so that the working functions in question may be adapted to a higher extent to the current treatment situation, and so that connected control functions for predetermined instruments or hand grips, such as the number of revolutions for a motor-driven instrument and humidity and/or amount of spray coolant in the case of use thereof, may be adapted to each other.

This object is obtained according to the invention in that for at least one of said dynamic instruments or

hand grips, a working memory associated with the microprocessor contains operational parameters for at least two different variation characteristics for one or more connected control functions for said instrument or hand grip for implementation of said function or functions by the use of said movable control member.

The control functions for dynamic instruments or instrument hand grips comprised by the invention may typically comprise the number of revolutions and/or the torque for an electric motor-driven hand grip, control of the amount of air for a turbine-driven hand grip, and/or power control for an ultrasound dental cleaning device. In case of connected control functions for a certain instrument or hand grip, the control functions will also typically comprise control of the air/water composition and/or air/water amount of a spray liquid which is supplied to a motor or turbine-driven instrument or an ultrasound dental cleaning device, for example with a view to cooling.

By rendering possible two or more different variation characteristics for a certain control function, which is to mean the relation between the present value of the operational parameter in question and the activation of the movable control member of the instrument operator device, the work function to be performed may be adapted to the current treatment situation, including the condition of the patient and the type of the current treatment task. To enable selection of a variation characteristic among several possibilities, an operator interface device having an operating member for selection of one of said control characteristics is further preferably associated with the microprocessor.

To facilitate the monitoring, some kind of display device for display of the variation characteristic in question is also preferably associated with the micro-

processor. In more simple embodiments, such a display may have a rather simple digital or alphanumeric design, for example in the form of a line screen.

Alternatively, the display may be effected by means of an operating and monitoring display of the type disclosed in said EP patent No. 0 391 967, such a display also being used for the performance of the selection and activation of the instrument operating and auxiliary functions mentioned in said patent.

Such an operating display with selection switches is thus also utilized as an operator interface device for the selection of desired characteristics for one or more control functions for the selected instrument.

However, the scope of the invention is in no way restricted to this embodiment, as a number of other forms of interface devices may be applied without injuring the primary requirement for a simple and reliable operation.

In relatively simple embodiments, it will thus be possible to use the foot switch itself as an operator interface device, as the operating member for selection of a characteristic may be constituted either by the actual movable control member of the instrument operation or a separate operating member, for example a kind of joystick, which is known per se from the above EP patent No. 0 391 967. In connection with an operating and monitoring display as mentioned above, the foot switch may also be used as an alternative interface device for the selection switches associated with the display, so that two different operation possibilities are available.

In a more advanced embodiment, the dental apparatus according to the invention may be designed with a view to speech control by the operator interface device being constituted by a speech control module, as the charac-

teristics which have to be selectable, may be identified by relatively simple and easily recognizable words of command.

A representative, but non-restrictive embodiment of a dental apparatus according to the invention will now be explained in further detail below with reference to the schematic drawings, in which

Fig. 1 is a schematic block diagram showing the essential system units of a dental apparatus, necessary to understand the invention,

Fig. 2 shows a preferred embodiment of a combined operator interface and display unit,

Figs. 3 and 4 show examples of alternative variation characteristics for connected control functions for a motor-driven instrument hand grip, and

Figs. 5 and 6 are examples of depictions of characteristics for control functions for a turbine-driven instrument and an ultrasound dental cleaning device.

In Fig. 1, numeral 1 designates a dynamic instrument hand grip accommodating an energizing unit built into the instrument handle in the form of an electric micromotor with a reversible direction of revolution and variable numbers of revolutions, for example in the range of 100-40,000 rpm. The hand grip 1 is of the type to which various angular members may be connected by means of a snap coupling for receiving drills, polishing pads, etc.

Together with other dynamic instruments typically comprising a turbine-driven drilling instrument, an ultrasound dental cleaning device, a hardening lamp for composite filling materials and optionally a dental surgical laser instrument, the hand grip 1 is arranged in an instrument carrier 2, to which is connected an instrument detector 3 which transmits a signal to a

microprocessor 4 having a CPU 5 and a working memory 6, when an instrument is removed from its place in the instrument carrier 2.

Activation and control of a removed instrument is effected by means of a foot switch 7 with a movable control member 8 which, in the embodiment shown, is movable in both lateral directions from a neutral central position. The foot switch 7 may also be provided with a separate switch member in the form of a joystick 9 with four switching positions.

The foot switch 7 is connected with an instrument control circuit 10 with control means for supply of electric power, turbine driving air and water and air in a spray coolant depending on the instrument or hand grip selected and under control by the movable control member 8 of the foot switch 7 according to variation or control characteristics, for which operational parameters are stored in the working memory 6 of the microprocessor 4.

In the embodiment shown, an operator interface device 11 and a display device 12 are connected to the microprocessor 4 for selection of a display of variation or control characteristics, among other things.

In simple embodiments of a dental apparatus according to the invention, where it should only be possible to select between two different variation characteristics for the number of revolutions for the micromotor in the hand grip 1, the display device 12 may actually be omitted, and the selection operation may be effected by using the foot switch 7 itself as the operator interface, either by the switch being effected by a movement of the movable control member 8 different from the instrument activating movement, or by means of the separate switch member, for example the joystick 9.

However, in a preferred embodiment, the operator interface device 11 and the display device 12 are combined in a physical unit in the form of an operating and monitoring display 13 shown in Fig. 2 and being of the type disclosed in principle in said EP patent No. 0 391 967.

In the embodiment shown, the image screen of the operating and monitoring display 13 is designed with a matrix arrangement with four columns A, B, C, and D, and four rows I, II, III, and IV so that it may contain a total of sixteen function display fields and may be used for monitoring and activation of all instrument operating and auxiliary functions in the dental apparatus such as explained in said EP patent.

Said operating and auxiliary functions may be organized in sets in a hierarchically structured menu system, and as also known from said EP patent, the dental apparatus may be provided with a mode switch which renders possible the performance of a number of auxiliary functions not directly associated with the operation of instruments.

Depending on the operating mode determined by the signal transmission made from the instrument detector 3 to the microprocessor 4, the selection or activation of instrument operating functions and auxiliary functions may be effected either by use of the foot switch 7 as an operator interface or by means of an arrangement of selection switches directly associated with the display 13 and, as explained in said EP patent, being provided by means of intersecting IR or UV rays 14 and 15 along the columns and rows of the matrix arrangement.

The two bottom rows III and IV on the image screen of the display 13 may be used for display and selection of the variation or control characteristics for the instrument control functions which are the subject of

the present invention, so that there are four image fields A, B, C, and D available for this purpose.

In the examples illustrated in Figs. 3-6, the left image field A displays an icon identifying the instrument or hand grip removed from the instrument carrier, viz. in Figs. 3 and 4 an icon 16 for a hand grip with an electric micromotor, in Fig. 5 an icon 17 for a turbine-driven instrument, and in Fig. 6 an icon 18 for an ultrasound cleaning device.

The following field B displays both an icon identifying a first control function for the selected instrument or hand grip, viz. in Figs. 3-5 an icon 19 identifying the number of revolutions for a micromotor or a driving turbine, respectively, and in Fig. 6 an icon 20 identifying the electric power supply to the ultrasound cleaning device, and a graphic image of a variation or control characteristic for the first control function in question.

Figs. 3 and 4, respectively, thus show a linear and non-linear variation characteristic 21 and 22, respectively, for the micromotor-driven hand grip represented by the icon 16. Each of the characteristics displayed indicates the numbers of revolutions at the lower and upper ends of the variation range. The linear control in Fig. 3 may, for example, be used when the speed is to be controlled within a relatively small variation range, for example as shown 8,000-17,000 rpm, while the non-linear control shown in Fig. 4 is particularly suitable when stepless control is desired within a large variation range, for example 100-40,000 rpm with a high accuracy of control in the lower part of this range.

As illustrated in Figs. 3 and 4, different variations characteristics for the same hand grip may be selected, and this option is consequently displayed on the screen by means of a downward arrow icon 23 under

the graphic image of the variation characteristic 21 and 22, respectively, corresponding to an arrow sign in one of the overlying function display fields CII, to express the fact that a switch between the different variation characteristics may be effected by means of the selection switch associated with this field.

As another possibility, this selection may be effected by means of the movable control member 8 or the joystick 9 of the foot switch 7.

Correspondingly, in Figs. 3 and 4, field C shows two different variation characteristics for a second control function connected with the first control function, viz. supply of spray water to the coolant applied when using the hand grip in question. Also in this case, the control function is identified by means of a symbol icon 24, and the current variation characteristic is shown by a graphic image, a linear characteristic 25 in Fig. 3, and a stepped characteristic 26 in Fig. 4, respectively, in the example shown. Numerical values for the lower and upper limits of the variation range are indicated in ml/min for this control function.

The possibility of selection between the two variation characteristics 25 and 26 is here indicated by an upward arrow icon 27 corresponding to an arrow sign in the overlying function field DII.

Finally, field D indicates the supply of air to the spray coolant represented by a symbol icon 28 and expressed in per cent of the maximum possible amount of air. In Fig. 3, this amount of air is constant in the full variation range, for example 70 per cent, corresponding to the fact that the relative water content of the coolant according to the characteristic 25 in field C is increased along with the increase in the number of revolutions. In Fig. 4, field D indicates a stepped characteristic with two values for the air supply

associated with a respective one of the two values of the water supply according to the characteristic in field C. The possibility of choice between the two characteristics in field D is again shown by means of an arrow icon 29 which also here corresponds to an arrow sign in an overlying function field, which, however, is not shown in the figure.

For the turbine-driven instrument represented by the icon 17 in Fig. 5, field B both displays the icon 19 for the number of revolutions and a graphic image 30 illustrating that the number of revolutions expressed as a percentage of the supply of turbine driving air corresponding to the maximum number of revolutions of, for example, 400,000 rpm, is kept constant over the whole variation range.

However, also in this case, as marked by the arrow icon 23, there is a possibility of another variation characteristic, for example a stepped characteristic with one speed value in a lower part of the variation range and another speed value in an upper part of the variation range.

Similarly to the manner of Figs. 3 and 4, fields C and D of Fig. 5 show variation characteristics 31 and 32 for spray water and spray air, respectively, with associated symbol icons 24 and 28 and arrow icons 27 and 29.

In the example shown in Fig. 6 of a display of variation characteristics for control functions for an ultrasound cleaning device as represented by icon 18, field B shows a graphic image of a step function for the electric power supply identified by the symbol icon 20. The quantitative indications of the power supply in the two steps have also here been indicated in per cent of the maximum power supply possible. In the same manner as in Figs. 3-5, fields C and D indicate the control

functions for spray water and spray air, field C by a linear control characteristic 33, and field D by a percentage indication which is 0 per cent in this example, corresponding to work without air supply in the spray.

Also this example provides a possibility of switching to other variation characteristics for the same control functions indicated by arrow icons 23, 27 and 29.

The examples illustrated in Figs. 3-6 only constitute representative illustrative examples of the possibilities of application of the invention. As already mentioned above, the application possibilities may be extended to comprise any control function for a dynamic instrument, for which there may be a desire to be able to work according to different variation characteristics during the performance of the function in question by operation of the movable control member of the foot switch.

As further concrete examples of this may be mentioned control of intensity and/or amount of energy for a composite hardening lamp for hardening of composite filling materials and control of intensity and/or pulse frequency for a laser surgical instrument.

The invention likewise comprises the case where, for a given dynamic instrument, in case of two connected control functions, only one variation characteristic for each of these functions is used, which characteristics are adapted to each other.

The possibility specially provided for by the invention of control of the spray coolant supply in dependency of the chosen control characteristic for the number of revolutions of the motor or the turbine may be accompanied by a corresponding adaptation of the

suction function used for removal of the coolant sprayed out.

The operational parameters associated with the variation characteristics for the individual control functions may either have permanently coded values determined from the function control used most frequently for the individually occurring treatment operations.

However, they may also be user-programmable, in the embodiment shown using an operating and monitoring display, for example by the use of programming menus, such as explained in EP patent No. 0 391 967. This possibility is an advantage, especially if the dental apparatus is designed for a multi-user application, as explained in said EP patent.

PATENT CLAIMS

1. A dental apparatus having an instrument arrangement comprising a carrier (2) for dynamic instruments (1) or instrument hand grips with associated energizing units, a detector device (3) responsive to the removal of an instrument or hand grip from its carrier, an instrument operator device (7) with a movable control member (8) for activating and controlling a selected instrument and for controlling auxiliary functions in conjunction with the operation thereof, and a microprocessor (4) for monitoring and controlling the operating functions of the instruments and their auxiliary functions, characterized in that for at least one of said dynamic instruments or hand grips, a working memory (6) associated with the microprocessor (4) contains operational parameters for at least two different control variation characteristics for one or more connected control functions for said instrument or hand grip for implementation of said function or functions by the use of said movable control member (8).

2. A dental apparatus according to claim 1, characterized in that said variation characteristics comprise at least two different control characteristics for the same control function, and that an operator interface device (11) having an operating member for selection of one of said control characteristics is further associated with the microprocessor (4).

3. A dental apparatus according to claim 1 or 2, characterized in that a display device (12) for display of said variation characteristics is also associated with the microprocessor.

4. A dental apparatus according to any one of claims 1-3, characterized in that the instrument operator device (7) comprises a foot switch

with a movable control member (8), and that the foot switch also constitutes said operator interface device.

5. A dental apparatus according to claim 4, c h a r a c t e r i z e d in that the movable control member (8) of the foot switch (7) in itself constitutes the operating member for said operator interface device by activation by a movement different from the instrument operation movement.

6. A dental apparatus according to claim 4, c h a r a c t e r i z e d in that the operating member for the operator interface device is constituted by a separate operating member (9) on the foot switch (7).

7. A dental apparatus according to claim 2 and 3, c h a r a c t e r i z e d in that the display device comprises an operating display (15) associated with the microprocessor (4) and having a matrix arrangement (A-D, E-N) of function display fields and selection switches (14, 15) selectively associated therewith, of which some function display fields are used for display of said variation characteristics and the associated selection switches as an operating member for the operator interface device.

8. A dental apparatus according to claim 2, c h a r a c t e r i z e d in that said operator interface device comprises a finger-operated keyboard.

9. A dental apparatus according to claim 2, c h a r a c t e r i z e d in that said operator interface device comprises a speech control device.

10. A dental apparatus according to any one of the preceding claims, c h a r a c t e r i z e d in that said control function(s) comprise(s) the number of revolutions and/or the torque of an electric motor-driven instrument hand grip.

11. A dental apparatus according to any one of the preceding claims, c h a r a c t e r i z e d in that

said control function(s) comprise(s) control of the amount of air for a turbine-driven instrument.

12. A dental apparatus according to any one of the preceding claims, c h a r a c t e r i z e d in that said control function(s) comprise(s) power control of an ultrasound dental cleaning device.

13. A dental apparatus according to any one of claims 10-12, c h a r a c t e r i z e d in that said connected control functions further comprise control of the air/water composition and/or air/water amount in a spray coolant supplied to said motor-driven hand grip, turbine-driven instrument or ultrasound cleaning device.

14. A dental apparatus according to any one of the preceding claims, c h a r a c t e r i z e d in that said control function(s) comprise(s) control of intensity and/or amount of energy for a light source for the hardening of composite filling materials.

15. A dental apparatus according to any one of the preceding claims, c h a r a c t e r i z e d in that said control function(s) comprise(s) intensity and pulse frequency for a laser surgical instrument.

16. A dental apparatus according to claim 7, c h a r a c t e r i z e d in that said operational parameters are user-programmable in that a programming menu is associated with the microprocessor and the operating display associated therewith.

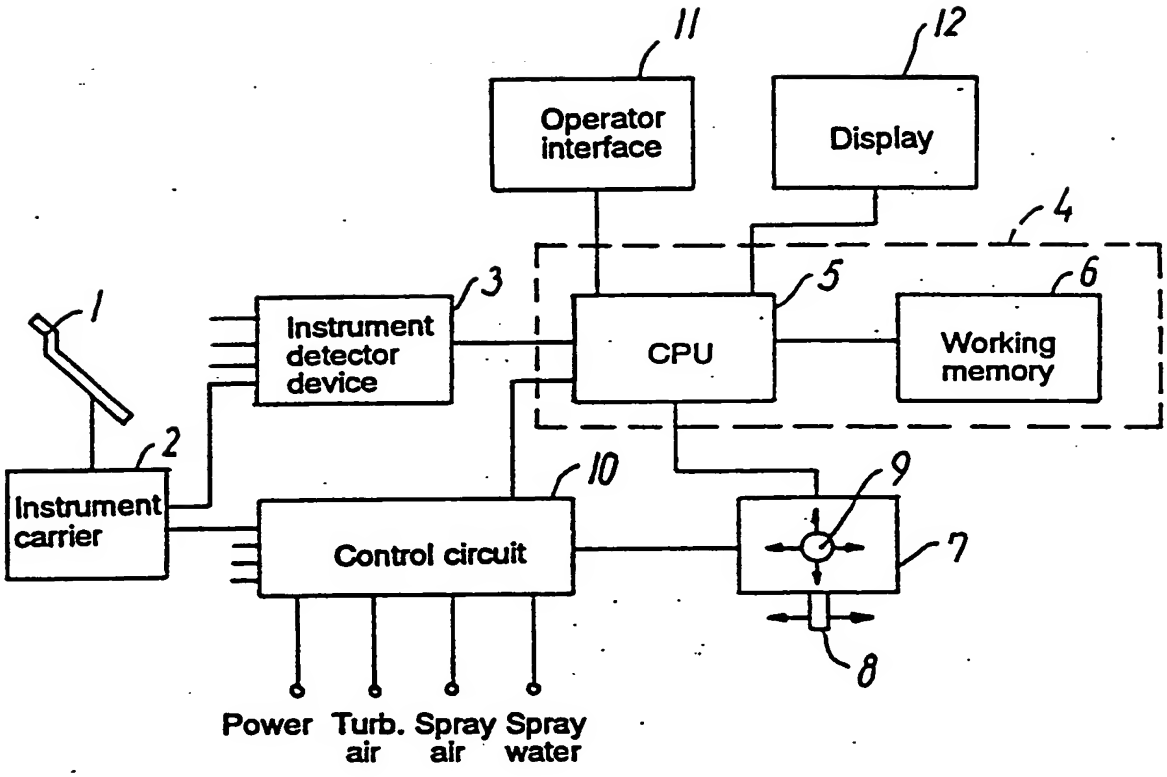
11
12
Operator interface
Display
4
1
3
5
6
Instrument detector device
CPU
Working memory
2
10
9
Instrument carrier
Control circuit
7
8
Power
Turb. air
Spray air
Spray water

FIG. 1

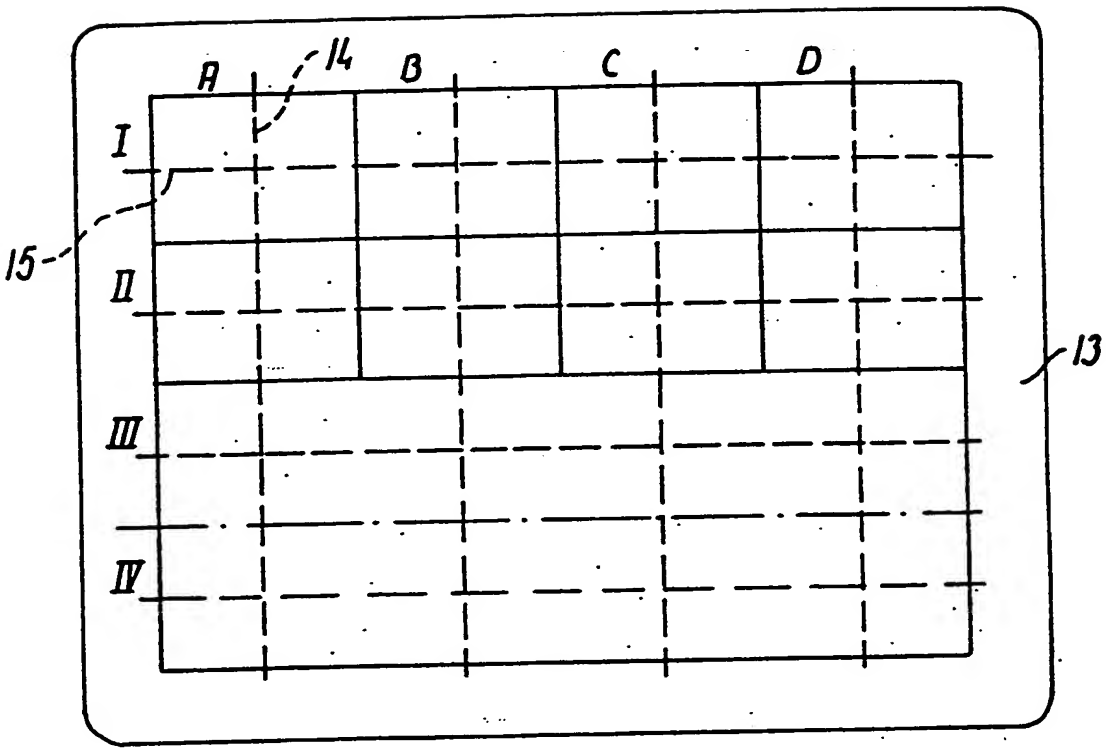

FIG. 2

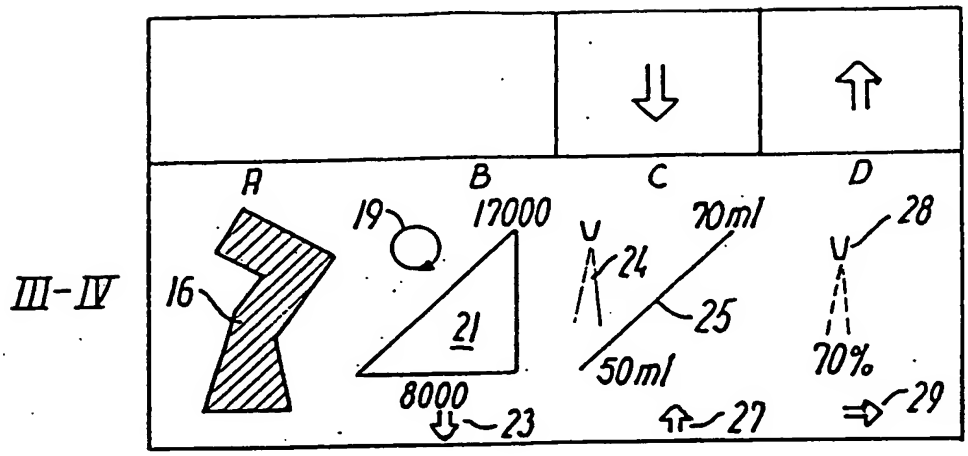

FIG.3

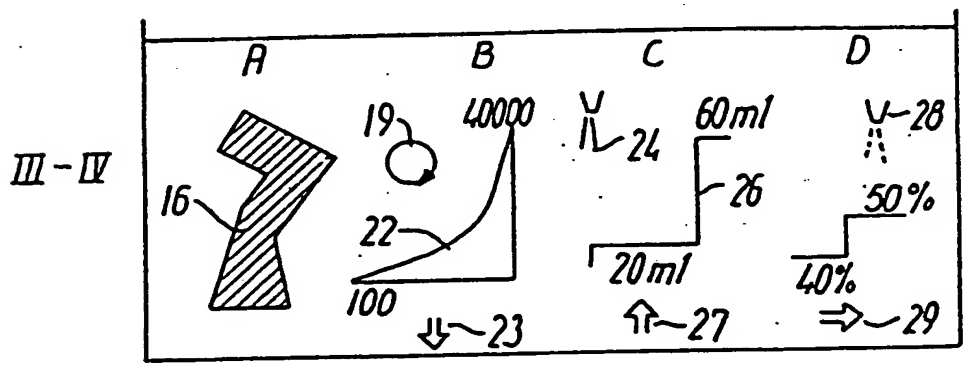

FIG.4

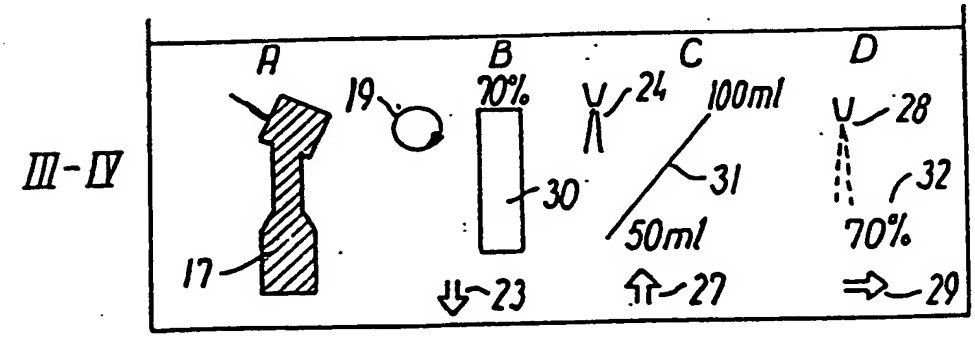

FIG.5

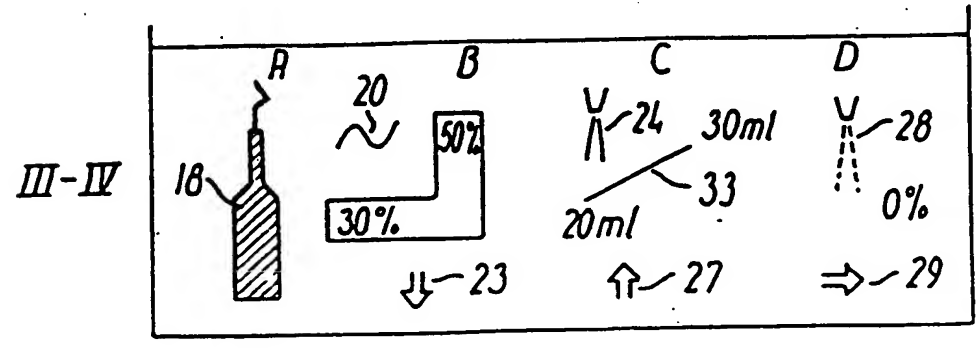

FIG.6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 93/00374

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: A61C 1/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: A61C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO, A1, 8905613 (DENFLEX A/S), 29 June 1989 (29.06.89)	1

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
21 February 1994	25 -02- 1994
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Jack Hedlund Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

28/01/94

International application No.
PCT/DK 93/00374

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A1- 8905613	29/06/89	DE-A- 3873776	17/09/92
		EP-A,B- 0391967	17/10/90
		JP-T- 3501690	18/04/91